Scapula fractures: interobserver reliability of classification and treatment

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Abstract: OBJECTIVES:There is substantial variation in the classification and the management of scapula fractures. The first purpose of this study was to analyze the interobserver reliability of the OTA/AO and the New International Classification of scapula fractures. The second purpose was to assess the proportion of agreement among orthopaedic surgeons on operative or nonoperative treatment. DESIGN:: Web-based reliability study SETTING:: Independent orthopaedic surgeons from several countries were invited to classify scapular fractures in an online survey. PARTICIPANTS:One-hundred and three orthopaedic surgeons evaluated 35 movies of 3DCT-reconstruction of selected scapular fractures, representing a full spectrum of fracture patterns. MAIN OUTCOME MEASUREMENTS:Fleiss' kappa ( ) was used to assess the reliability of agreement between the surgeons. RESULTS:: The overall agreement on the OTA/AO Classification was moderate for the types (A, B, and C, = 0.54) with a 71% proportion of rater agreement (PA) as well as for the nine groups (A1 to C3, = 0.47) with a 57% PA. For the New International Classification, the agreement about the intra-articular extension of the fracture (Fossa (F), = 0.79) was substantial, the agreement about a fractured body (Body (B), = 0.57) or process was moderate (Process (P), = 0.53), however PAs were more than 81%. The agreement on the treatment recommendation was moderate (= 0.57) with a 73% PA. CONCLUSIONS:The New International Classification was more reliable. Body and process fractures generated more disagreement than intra-articular fractures and need further clear definitions.

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Scapula Fractures: Interobserver Reliability of Classification and Treatment

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Objectives: There is substantial variation in the classification and management of scapula fractures. The first purpose of this study was to analyze the interobserver reliability of the OTA/AO classification and the New International Classification for Scapula Fractures. The second purpose was to assess the proportion of agreement among orthopaedic surgeons on operative or nonoperative treatment.

Design: Web-based reliability study.

Setting: Independent orthopaedic surgeons from several countries were invited to classify scapular fractures in an online survey.

Participants: One hundred three orthopaedic surgeons evaluated 35 movies of three-dimensional computerized tomography reconstruction of selected scapular fractures, representing a full spectrum of fracture patterns.

Main Outcome Measurements: Fleiss kappa (κ) was used to assess the reliability of agreement between the surgeons.

Results: The overall agreement on the OTA/AO classification was moderate for the types (A, B, and C, $\kappa = 0.54$) with a 71% proportion of rater agreement (PA) and for the 9 groups (A1 to C3, $\kappa = 0.47$) with a 57% PA. For the New International Classification, the agreement about the intraarticular extension of the fracture (Fossa (F), $\kappa = 0.79$) was substantial and the agreement about a fractured body (Body (B), $\kappa = 0.57$) or process was moderate (Process (P), $\kappa = 0.53$); however, PAs were more than 81%. The agreement on the treatment recommendation was moderate ($\kappa = 0.57$) with a 73% PA.

Conclusions: The New International Classification was more reliable. Body and process fractures generated more disagreement than intraarticular fractures and need further clear definitions.

Key Words: OTA/AO fracture classification, New International Classification for Scapular Fractures, reliability, scapula

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INTRODUCTION

Our traditional complacence with fractures of the shoulder girdle was altered by recent data showing that operative treatment of displaced clavicle fractures reduces the risk of nonunion and pain as well as improves functional results.[1–3] Now, some are suggesting that more frequent operative treatment of scapula fractures should be considered.[4–9] The indications for surgery are not clearly defined, and the role of classification schemes is uncertain. A New International Classification for Scapular Fractures was recently developed by a study group of 6 orthopaedic trauma surgeons hoping to develop a better fracture classification system and later to clarify the prognostic value of it for indications for operative treatment.[10]

This study sought to compare the OTA/AO classification with the New International Classification for Scapular Fractures. Our primary study aim was to measure the reliability of the OTA/AO classification and the New International Classification for Scapula Fractures. The second aim was to evaluate the agreement on operative treatment.

PATIENTS AND METHODS

Study Design

Orthopaedic surgeons from 25 countries participating in the Science of Variation Group, a web-based collaborative of experienced orthopaedic surgeons, were invited to evaluate and rate 35 movies of three-dimensional computerized tomography (3DCT) reconstruction of scapular fractures in an online survey in May and June 2012.[11] The movies were presented online in a random order and were assessed independently by the raters. A description of the OTA/AO[12] classification and the New International Classification[10] was provided for each movie. No other information (additional injuries, treatment, outcome) was made available. The raters were asked to classify the presented scapular fractures (OTA/AO and the New International Classification) and to propose operative or nonoperative treatment in young, active, and healthy patients. There was no time limit to complete the questionnaire.

Raters

One hundred sixty-eight (21%) of the 802 invited surgeons agreed to participate in the study (a large percentage of our collaborative do not treat scapula fractures), and 103 surgeons (61%) completed all questions (Table 1). They were not involved in the treatment of the patients presented in this study cohort and did not receive any incentives other than an acknowledgement in this article.

TABLE 1. Surgeons' Demographics

Parameter	n
All questions answered	103
Sex	
Male	96
Female	7
Area of practice	
Australia	4
Canada	4
Europe	28
United Kingdom	3
United States	47
Other	17
Years of independent practice	
0–10	51
More than 10 years	52
Specialization	
Orthopaedic traumatology	44
Shoulder and elbow	23
Hand and wrist	25
General orthopaedics or other	11

n, number of surgeons.

Fractures

Under Institutional Review Board approval (protocol #: 2009-P-001019/89; Massachusetts General Hospital), a total of 457 scapular fractures were identified from a prospectively collected trauma database (from 2002 to 2011) at two level 1 trauma centers. Inclusion criteria were as follows: (1) adult patients (≥18 years) and (2) adequate quality (slice thickness ≤2.5 mm) and completeness of computed tomographies for 3D reconstruction, leaving a cohort of 225 suitable fractures. Thirty-five fractures were selected with complete, high-quality CTs and representing a full spectrum of scapular fracture patterns. Sex, age, side, concomitant injuries, Injury Severity Score, radiological measurements (intraarticular step-off, medialization, translation, angulation, glenopolar angle, presence of a double disruption of the superior shoulder suspensory complex), and the received treatment (either operative or nonoperative) were independently of the surgeons' ratings recorded for readers information. The radiographic measurements were performed with the Aquarius workstation (Version 4.4.6; TeraRecon, Inc., San Mateo, CA) for one institution and with the Centricity software (GE Healthcare, Buckinghamshire, United Kingdom) for the other institution by an independent experienced orthopaedic surgeon. The movies were created with Osirix[13] (OsiriX Foundation/Pixmeo, Geneva, Switzerland) and were rotating (360 degrees around a vertical axis with a duration of 10 seconds) 3DCT reconstructions of the whole scapula with humerus and clavicle subtracted. The raters could replay the videos as needed.

Statistical Analysis

For each fracture, the most commonly proposed answers and the proportion of agreement (in percentage, PA) were presented and analyzed. The multirater agreement of the nominal variables (OTA/AO classification; the New International Classification; recommended treatment) were calculated with the Fleiss generalized Kappa,[14,15] which is a statistical chance-corrected measure for assessing multirater agreement with binary or nominal ratings. The calculated measures are presented as a value between 0 and 1 and are called Kappa value. They were interpreted in accordance to the guidelines by Landis and Koch[16]: 0.01–0.20 represent slight agreement, 0.21–0.40 fair agreement, 0.41–0.60 moderate agreement, 0.61–0.80 substantial agreement, and above 0.81 is considered almost perfect agreement. In another study, a value of 0.70 was considered an adequate sign of reliability.[17]

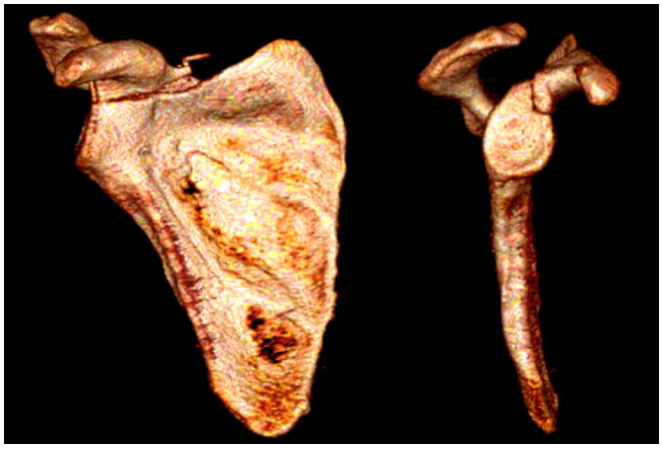

FIGURE 1. Anterior and Y-view of the 3DCT reconstruction (fracture 11). Surgeons had problems deciding if the body and/or the process was involved. **Editor's note**: A color image accompanies the online version of this article.

RESULTS

OTA/AO Classification

The proportion of the most proposed AO group of all answers varied between 26% and 99% for the 35 cases. The

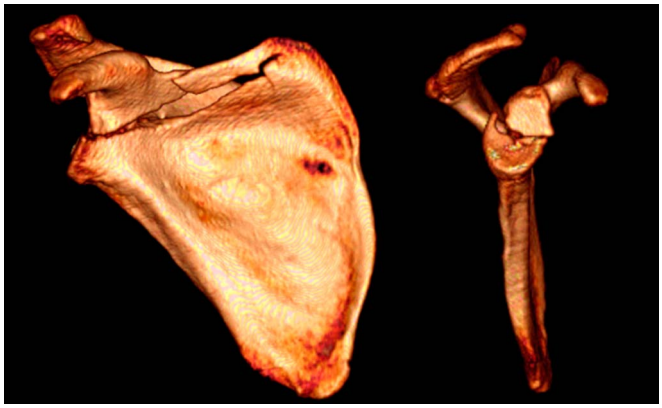

FIGURE 2. Forty-three percent of the raters classified fracture 9, which is very similar to fracture 3, as a C2 fracture (total articular; intraarticular fracture with neck) and 40% as a C3 fracture (intraarticular fracture with body). **Editor's note**: A color image accompanies the online version of this article.

TABLE 2. OTA/AO Classification

Fracture No.	Raters (n)	Most Proposed AO Type	% All Answers
1	162	C3	59
2	153	A3	95
3	137	C2	26
4	131	A3	99
5	131	A3	99
6	129	A1	99
7	124	A3	75
8	119	C3	70
9	115	C2	43
10	114	A2	94
11	111	B1	41
12	110	A3	78
13	109	C3	52
14	108	A3	82
15	107	A1	93
16	106	A3	88
17	106	C3	69
18	105	A3	35
19	103	A3	96
20	103	A3	84
21	103	B1	34
22	103	C3	40
23	103	B1	72
24	103	C3	56
25	103	B3	75
26	103	A3	88
27	103	C3	61
28	103	C2	60
29	103	B3	43
30	103	C1	64
31	103	A3	77
32	103	C3	69
33	103	A3	82
34	103	C3	69
35	103	C3	55

Parameter	Agreement	Kappa	PA (%)
Overall			
3 Types (A, B, C)	Moderate	0.54	71
9 Groups (A1 - C3)	Moderate	0.47	57
Years of practice			
0–10	Moderate	0.48	58
More than 10 years	Moderate	0.46	56
Specialization			
Orthopaedic traumatology	Moderate	0.46	56
Shoulder and elbow	Moderate	0.51	61
Hand and wrist	Moderate	0.43	53

most proposed AO group was A3 in 13 fractures, C3 in 10 fractures, B1 in 3 fractures, C2 in 3 fractures, and other groups in 6 fractures. The overall agreement on the OTA/AO classification was moderate for the 3 types of fracture (κ = 0.54) with a 71% PA and for the 9 groups of fracture (κ = 0.47) with a 57% PA. There was a higher agreement on type A fractures (κ = 0.72), and a lower one on type C (κ = 0. 46) and B (κ = 0.37) fractures. Although the agreements on the groups A1 (κ = 0.77), A3 (κ = 0.74), and A2 (κ = 0.65) were highest, they were lowest for the C1 (κ = 0.25), C2 (κ = 0.20), and B2 (κ = 0.02) fractures. Most disagreements were between B1 (anterior rim fracture), C2 (intraarticular fracture with neck), and A2 (coracoid fracture). For example, 41% of the raters classified fracture 11 (Fig. 1) as an AO type B1 (partial articular; anterior rim fracture), 28% as an A2 (extra-articular coracoid fracture), and 19% as a C2 (intraarticular fracture with neck). Another point of disagreement was between C2 (intraarticular fracture with neck) and C3 (intra-articular fracture with body) in certain circumstances (Fig. 2). The years of practice did not affect the degree of overall agreement. Shoulder surgeons were more likely to agree on the OTA/AO classification (Table 2).

New International Classification

Agreement about the intraarticular extension of the fracture was substantial (κ = 0.79, PA 90%), and for shoulder and hand surgeons almost perfect (κ = 0.83 and κ = 0.80, respectively). The agreement about a fractured body (κ = 0.57, PA 82%) or process was moderate (κ = 0.53, PA 80%). Another source of disagreement was fracture of the glenoid neck (Fig. 3), which was less of a problem with the OTA/AO classification. The further in-depth classification showed a fair agreement for body fractures (B1, B2, or B not applicable; κ = 0.35, PA 58%) and a moderate agreement on fractures involving the fossa (F0, F1, F2, or F not applicable; κ = 0.59, PA 74%) as well as process fractures (P1, P2, P3, or P not applicable; κ = 0.46, PA 73%) (Table 3).

Recommended Treatment

Nonoperative treatment was most often recommended in 21 fractures and operative treatment in 14 fractures.

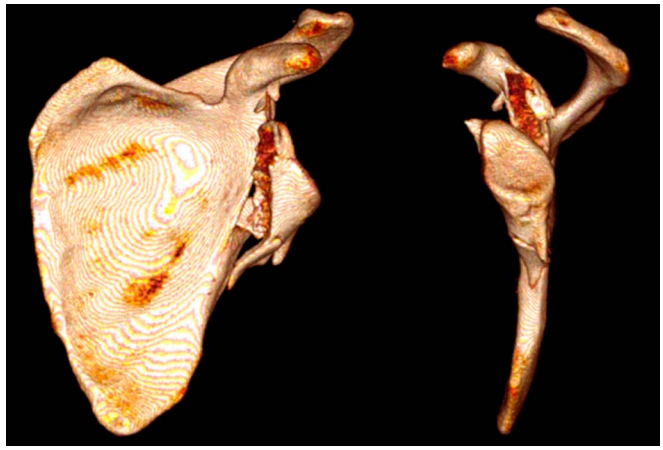

FIGURE 3. Glenoid neck fracture (fracture 30) caused a high disagreement in the New International Classification; it was classified as a body fracture in 63% and as an intraarticular fracture in 54%. **Editor's note**: A color image accompanies the online version of this article.

TABLE 3. New International Classification for Scapular Fractures

Fracture No.	Raters (n)	Body (B)	% All Answers	Fossa (F)	% All Answers	Process (P)	% All Answers
1	162	Fractured	81	Intraarticular	97	Not involved	99
2	153	Fractured	99	Extraarticular	98	Not involved	100
3	137	Not fractured	55	Intraarticular	68	Involved	52
4	131	Fractured	100	Extraarticular	99	Not involved	99
5	131	Fractured	100	Extraarticular	98	Not involved	94
6	129	Not fractured	98	Extraarticular	100	Involved	98
7	124	Fractured	92	Extraarticular	98	Involved	61
8	119	Fractured	79	Intraarticular	96	Not involved	62
9	115	Not fractured	51	Intraarticular	97	Involved	72
10	114	Not fractured	98	Extraarticular	99	Involved	99
11	111	Not fractured	95	Intraarticular	77	Involved	68
12	110	Fractured	96	Extraarticular	93	Not involved	95
13	109	Fractured	80	Intraarticular	93	Not involved	79
14	108	Fractured	99	Extraarticular	96	Not involved	100
15	107	Not fractured	79	Extraarticular	99	Involved	81
16	106	Fractured	98	Extraarticular	97	Not involved	98
17	106	Fractured	90	Intraarticular	97	Involved	73
18	105	Fractured	89	Extraarticular	61	Not involved	66
19	103	Fractured	98	Extraarticular	100	Not involved	96
20	103	Fractured	99	Extraarticular	97	Not involved	99
21	103	Not fractured	81	Intraarticular	90	Involved	64
22	103	Fractured	87	Intraarticular	94	Involved	81
23	103	Not fractured	100	Intraarticular	100	Not involved	100
24	103	Fractured	78	Intraarticular	97	Involved	55
25	103	Not fractured	98	Intraarticular	99	Not involved	100
26	103	Fractured	99	Extraarticular	99	Not involved	100
27	103	Fractured	77	Intraarticular	99	Not involved	96
28	103	Not fractured	85	Intraarticular	98	Involved	57
29	103	Fractured	67	Intraarticular	99	Not involved	99
30	103	Fractured	63	Intraarticular	54	Not involved	97
31	103	Fractured	97	Extraarticular	97	Not involved	100
32	103	Fractured	89	Intraarticular	97	Not involved	98
33	103	Fractured	99	Extraarticular	99	Not involved	99
34	103	Fractured	89	Intraarticular	97	Not involved	85
35	103	Fractured	86	Intraarticular	82	Not involved	94

	For Body (B)			For Fossa (F)			For Process (P)		
Parameter	**Agreement**	**Kappa**	**PA (%)**	**Agreement**	**Kappa**	**PA (%)**	**Agreement**	**Kappa**	**PA (%)**
Overall	Moderate	0.57	82	Substantial	0.79	90	Moderate	0.53	81
Years of practice									
0–10	Moderate	0.59	83	Substantial	0.79	90	Moderate	0.55	82
More than 10 years	Moderate	0.57	80	Substantial	0.79	90	Moderate	0.52	80
Specialization									
Orthopaedic traumatology	Moderate	0.55	80	Substantial	0.78	89	Moderate	0.52	81
Shoulder and elbow	Substantial	0.61	85	Almost perfect	0.83	92	Moderate	0.54	81
Hand and wrist	Moderate	0.53	79	Almost perfect	0.80	90	Moderate	0.52	80

The agreement was moderate ($\kappa = 0.57$) with an average PA of 73%, ranging from 52% to 98% with similar agreement for operative and nonoperative recommendations. More experienced doctors were less likely to recommend operative treatment. The specialization did not affect the treatment recommendation (Table 4).

DISCUSSION

We found moderate overall agreement regarding classification of scapular fractures, better for articular than for body or process involvement. The average proportion of observers agreeing with the most popular treatment recommendation was 73%.

TABLE 4. Recommended Treatment

Fracture No.	Raters (n)	Recommended Treatment	% All Answers
1	162	Operative	82
2	153	Nonoperative	98
3	137	Nonoperative	58
4	131	Nonoperative	98
5	131	Nonoperative	91
6	129	Nonoperative	52
7	124	Nonoperative	56
8	119	Operative	89
9	115	Operative	90
10	114	Operative	52
11	111	Nonoperative	65
12	110	Nonoperative	96
13	109	Nonoperative	72
14	108	Nonoperative	63
15	107	Nonoperative	84
16	106	Nonoperative	95
17	106	Operative	69
18	105	Nonoperative	81
19	103	Nonoperative	98
20	103	Nonoperative	83
21	103	Nonoperative	78
22	103	Operative	52
23	103	Operative	97
24	103	Operative	91
25	103	Nonoperative	79
26	103	Nonoperative	88
27	103	Operative	87
28	103	Operative	97
29	103	Operative	55
30	103	Operative	87
31	103	Nonoperative	71
32	103	Operative	90
33	103	Nonoperative	88
34	103	Operative	92
35	103	Nonoperative	90

Parameter	Agreement	Kappa	PA (%)
Overall			
Recommended treatment	Moderate	0.45	73
Years of practice			
0–10	Moderate	0.48	75
More than 10 years	Moderate	0.41	71
Specialization			
Orthopaedic traumatology	Moderate	0.44	72
Shoulder and elbow	Moderate	0.45	73
Hand and wrist	Moderate	0.48	74

Readers should consider several limitations. The data may not be valid outside the group of surgeons that participate in the Science of Variation Group, although we feel that the large number of surgeons of various specialties and countries improves external validity beyond that of the typical reliability study. Nearly 40% of the participating surgeons did not answer all questions, which may have influenced our results. We did not measure the time surgeons spent looking at the movies, which could also correlate with agreement. In trying to present as many different fracture patterns as possible, we may have introduced a spectrum bias. For instance, intraarticular fractures were overrepresented.[17] However, an overpresentation of intraarticular fractures can rather positively contribute to the study as these fractures have more impact on the treatment decision and outcome. Other downsides were that surgeons could not rotate the 3D models to their needs, and Osirix may have affected the image resolution and consequently the interpretation of the fracture patterns by rendering issues. However, all surgeons had the same kind of movies to interpret, which equalizes these problems. And last, there was no way to assess accuracy as there is no gold standard/reference classification.

The OTA/AO classification distinguishes extra-articular (type A), partial articular (type B), and complete articular (type C) fractures. Although the agreement for type A scapula fractures was substantial, the agreement about types B and C was moderate or even fair for some subgroups. In comparison, the overall agreement for diaphyseal fractures was higher in one recent study and the level of experience and specialization did not affect their results.[18] In our study, shoulder specialists had the best agreement. Perhaps an in-depth knowledge and greater familiarity with complex scapular anatomy and injuries may contribute to better understanding and classification of the fractures. Level of training is often associated with greater reliability when surgeons in training are observers,[19] but level of experience did not affect agreement in our study of fully trained surgeons. The lesser experience of younger surgeons may be balanced by their greater familiarity with 3DCTs and greater reliance on the definitions.[11]

The New International Classification for Scapula Fractures distinguishes fractures extending into the body, fossa, or processes. This classification had almost perfect agreement if the fracture lines extend into the glenoid fossa and moderate agreement on body and process fractures. In comparison, the expert panel in the development study[10] had comparable agreement on intraarticular ($\kappa = 0.78$) but a clearly higher agreement on process ($\kappa = 0.61$) or body fractures ($\kappa = 0.75$), which may indicate that their intensive dispute and training about scapula fracture classification and their knowledge about the definitions improved their agreement. This new classification helped us to better understand the reasons for disagreement of the raters with the OTA/AO classification.

Some surgeons advocate more frequent operative treatment of scapula fractures.[4–9] In 40% of our selected fractures, more than 50% of the surgeons recommended operative treatment. The agreement on treatment recommendation was only moderate, remains controversial, and merits further study.

In conclusion, the simpler New International Classification proved more reliable than the OTA/AO classification. Surgeons find it more difficult to distinguish body and process fractures than glenoid fractures. Improved definitions and training may further help to improve reliability of scapula fracture classification.[20]

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